

Article

Investigation of BTX Concentrations and Effects of Meteorological Parameters in the Steelpoort Area of Limpopo Province, South Africa

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Abstract: It has been demonstrated that benzene, toluene, and xylene are carcinogens. Its combined effects with other contaminants have the potential to harm several ecosystem components. Since most human benzene exposure takes place inside, it is important to understand how outdoor benzene emissions from traffic and industry affect interior concentrations. However, this area of study has not received enough attention to date. Herein, we examine the outdoor concentrations of benzene, toluene, and xylene (BTX) in a Steelpoort mining area. BTX pollutants were passively sampled on the first seven days of the month, from January to December 2021 using Radiello samplers. The effects of meteorological parameters such as temperature, relative humidity, wind speed, and solar radiation on BTX concentrations were also statistically tested. For all seasons, BTX concentrations were greater in the winter than in the summer with concentrations of $0.69 \mu\text{g}/\text{m}^3$, $2.97 \mu\text{g}/\text{m}^3$ and $0.80 \mu\text{g}/\text{m}^3$ for benzene, toluene and xylene, respectively. In addition, toluene was the most common BTX compound with the highest concentrations when compared to benzene and xylene. Benzene, toluene and xylene, had yearly average concentrations of $0.61 \mu\text{g}/\text{m}^3$, $1.48 \mu\text{g}/\text{m}^3$ and $0.64 \mu\text{g}/\text{m}^3$, respectively. The benzene and xylene concentrations were below international exposure limits (annual, $5 \mu\text{g}/\text{m}^3$ for benzene; weekly, $260 \mu\text{g}/\text{m}^3$ for toluene), as in comparison to the World Health Organization, as well as within South African exceedance limits. Both positive and negative correlations between BTX and meteorological parameters were demonstrated by statistical models. Temperature, wind speed, and relative humidity depicted a weak negative correlation with benzene of 0.003, 0.019 and 0.006, respectively. Toluene showed a positive correlation with wind speed (1.90) and relative humidity (0.041). Overall, the concentration of benzene is of major concern since it is an agent of cancer and it is there in the atmosphere.

Keywords: BTX; interspecies ratio; meteorological parameters; emission sources



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1. Introduction

Mono-aromatic volatile organic compounds (VOCs), such as benzene, toluene, and xylene (BTX), are among the most widely produced chemicals in the world [1–4]. These compounds are classified as hazardous air pollutants due to their potential to damage human health [5,6]. According to the International Agency for Research on Cancer, benzene, toluene and xylene are categorized as human carcinogen, probable human carcinogen and non-carcinogen for humans [7–9]. It has been reported that human beings are exposed to these volatile organic compounds through inhalation, which places their health at risk [10]. The effects of BTX exposure on human health have been extensively studied and are mostly influenced by exposure duration and concentration [11,12]. BTX, which can pollute air

through a variety of sources, such as cigarette smoke, motor vehicle fuel combustion, petrochemical industries and gasoline and diesel combustion have both short-term and long-term effects on human health [13]. Eye irritation, headache, vertigo, visual impairments, and memory disorders have been linked to short-term exposure to BTX [14–16], while long-term exposure was linked with leukaemia and biliary tract cancer; birth defects; damage to body organs such as the liver, kidney, and central nervous system; allergies; and asthmatic intensification. Toluene and xylenes are neurotoxic and cause peripheral neuropathies, while benzene is hematotoxic and considered to be the most toxic chemical among BTX [12,17]. Although children and the elderly groups are the most vulnerable groups due to their weaker immune system [18], studies show that children are at greater risk. This is due to their high metabolic and resting rate as compared to adults. Again, it was further found that children spend most of their time indoor next to their mothers, and they are thus exposed to elevated concentrations of combustion pollutants during cooking and heating conditions [19].

Studies on the fluctuations of BTX in metropolitan regions' atmosphere across time and space, in both established and developing nations, have demonstrated that BTX are linked to certain activities such as oil refineries, petrochemical industries and vehicle emissions [20,21]. Of all of the sources reported, gasoline is the one that has received much attention in the past decades [22–24]. The major component of gasoline is benzene, which is released from gasoline engines. The benzene-to-toluene (B/T) ratio is often applied as an index for determining the emission sources of BTX compounds [6,25,26]. A ratio exceeding 0.5 suggests that the source of benzene is not only related to traffic but also other sources. Moreover, B/T ratios lower than 0.5 suggest that transportation is the predominant source of BTX [27].

In South Africa, emissions of volatile organic compounds along with their corresponding concentrations are all considered to be major sources of air pollution. Pollutants released from a variety of sources such as the burning of biomass and home fuels, etc., have an impact on the quality of the air in different parts of the nation. [28]. Since there is no law in South Africa defining acceptable levels of VOCs in ambient air, it is more difficult to implement monitoring and emission reduction programs [19,29]. The only pollutant the South African government regularly monitors and limits in ambient air is benzene, even though toluene and xylenes have been shown to be harmful to human health. However, since TX is regarded as an ozone precursor substance, there has been a push in South Africa to include limits and guideline values for it. Furthermore, the South African government intended to further reduce benzene limits from 3 ppb to 1.5 ppb by 2016, with no exceedances (above limits) permitted as VOC levels rise [19,23].

BTX have been monitored in South Africa in areas such as Vaal Triangle, Cape Town, Johannesburg, Pretoria and Mpumalanga Highveld [30,31]. The passive sampling of BTX was investigated and found to range between 8.83 to 39.62 $\mu\text{g}/\text{m}^3$ in residential areas around Roodepoort, South Africa [32]. Also, seven-day median personal BTX exposure was collected using passive compact diffusive samplers [33]. Nonetheless, BTX levels have not been assessed in the Steelpoort mining area. This research will contribute to assessing the risk associated with BTX health effects for Steelpoort residents. Therefore, the aim of this study was to assess the air quality of the mining area in Steelpoort, specifically the VOCs such as benzene, toluene and xylene. The dataset contains concentrations of BTX from January 2021 to December 2021. Passive sampling was used because it has proven to be a methodology that fulfils the need for adopting inexpensive, simple and reliable methods for air quality monitoring. Therefore, the aim of the study was to investigate the outdoor concentrations of BTX by using Radiello[®] diffusive samplers. This study also uses the interspecies ratio to get the potential emission sources and statistical tests on meteorological factors affecting concentrations of BTX.

2. Materials and Methods

2.1. Study Area

Steelpoort is a mining area in Sekhukhune District Municipality in the Limpopo province. The altitude ranges from 1500 to 2400 m above sea level. Mean annual rainfall varies between 630 mm and 1000 mm, mainly in the form of summer thunderstorms. The settlement has an estimated population of approximately 1105, 380 (122.09 per km²) households and covers 3.11 km². It is also surrounded by five villages within a radius of ±10 km radius, namely Ga-Mahlokwane (3.8 km); Tukakgomo (3.8 km); Ga-Phasha (3.8 km); Ga-Mampuru (8.4 km); and Stocking (9.4 km). Also, Steelpoort is surrounded by eight mines, viz., Dwarsrivier Chrome; Tweefontein Chrome; Tubatse Ferrochrome; Two Rivers Platinum; Modikwa Platinum; Mototolo Platinum Mine; Lion Ferrochrome Smelter; and Marula Platinum (Pty) Ltd. as illustrated in Figure 1.

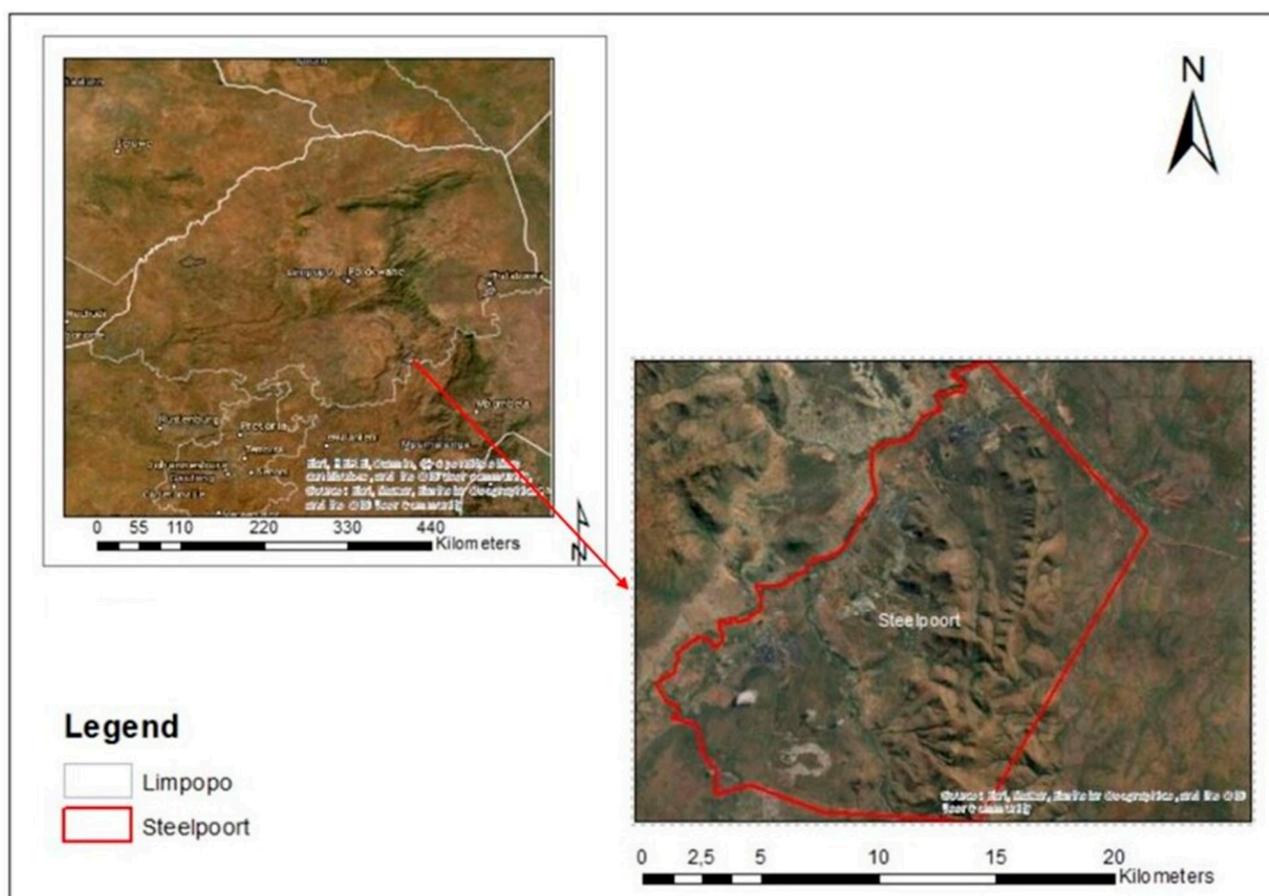


Figure 1. Map of Limpopo showing sampling site, Steelpoort.

2.2. Sampling Method

Radiello passive sampling cartridges were deployed to collect the air samples during a 7-day sampling session from January 2021 to December 2021. The samplers were placed at Ga-Mapodile Library which is 10 km away and on the western side of the Steelpoort mine. The sampling period was chosen because it represents varying seasonal climatic conditions. BTX were sampled by Radiello[®] diffusive samplers (Code RAD 130). The Code RAD130 cartridge has a very large loading capacity of about 80 mg. This corresponds to an overall VOC concentration of 3000–3500 mg/m³ sampled for 8 h or 70,000–80,000 µg/m³ for 14 days [34]. The adsorbing cartridge consists of a stainless steel net cylinder with a 100 mesh grid opening and 5.8 mm diameter containing 530 ± 30 mg of activated charcoal, which is enclosed in a white diffusive body. A mountable polypropylene shelter protected the sampler from bad weather and direct sunlight. The samplers were placed 1.5 m above

ground level at the sampling site. The samples were coded and transferred to the laboratory in a cold box at 4 °C for further analysis.

2.3. Analyses of BTX by Gas Chromatography

The cartridges used during sampling were transferred into vials and first fortified with 100 µL of 1-chlorooctane solution (internal standard with concentration of 10 µg/mL), then 2 mL carbon disulphide was added and the vials were immediately sealed with a septum cap. The samples were shaken for 30 min at room temperature, then 5 µL of the extract were analysed by GC-FID as outlined below. All samples were analysed on 7890A/5975C Triple-Axis Detector diffusion pump-based (Agilent, Santa Clara, CA, USA) GC-MS equipped with a split/splitless inlet. A 60 m × 0.25 mm HP-INNOWax (Agilent, USA) column with a film thickness of 0.25 µm was used for the separation of BTX. The constant flow of helium in the column was 1 mL/min. Temperatures of ion source, quadrupole and MS interface were 230, 150 and 250 °C, respectively. The thermal desorption of analytes from SPME fibre in GC injector was done in splitless mode at 250 °C using a 0.75 mm in diameter liner (Supelco, Bellefonte, PA, USA). Oven temperature was programmed from an initial 40 °C (held for 3 min) to 150 °C (held for 1.5 min) at the heating rate of 20 °C/min. As shown in Figure 2, the GC column separated BTX in different retention times, such as 11.49 min for benzene, 16.614 min for toluene and 22.7 to 24.02 min for xylene. It can be seen that xylene split into three distinct peaks at 22.7, 23.41 and 24.02 min (retention time), which are attributed to *m*-xylene, *p*-xylene and *o*-xylene, respectively. The peak around 28.416 min can be attributed to ethylbenzene. Detection was carried out in selected ion monitoring mode *t m/z* 78, 91 and 106 for the selective detection and quantification of the four BTX constituents, respectively. The total run time of the analysis was 10 min. The identification of compounds was carried out by comparing the characteristics peaks of the eluted sample with those of authentic analyte standards and GC retention times. The sample and the blanks were injected twice and the mean values were reported.

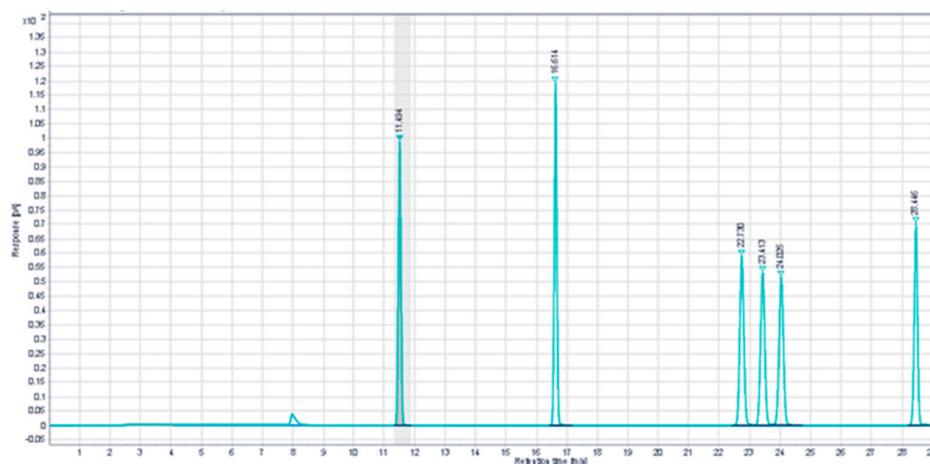


Figure 2. GC chromatogram of BTX: 1 = benzene, 2 = toluene and 3 = xylene, with relative standard deviations of 1.9%, 0.75% and 3.72%, respectively.

The mean concentration C ($\mu\text{g}/\text{m}^3$) of a specific BTX during the exposure time t is calculated using the following Equation (1)

$$C = m/Q \cdot t \times 10^6 \quad (1)$$

where m (μg) is the amount of analytes adsorbed on the cartridge, Q (mL/min) is the uptake rate at 298 K and t (min) is the sampling period. The Q values are given by the Radiello manual; at the normal conditions as defined by EC directives at $T = 293$ and $P = 101.3$ kPa, the Q values are 80 mL/min for benzene, 74 mL/min for toluene, 68 mL/min for ethylbenzene, 70 mL/min for (*m* + *p*)-xylenes and 68 mL/min for *o*-xylene.

Since the temperature and pressure were different from the normal conditions, the Q values were corrected using Equation (2):

$$Q_T = Q_{298}(T/298)^{1.5} \quad (2)$$

where Q_T is the sampling rate at the temperature T , and Q_{298} is the Q value at the normal condition. The relative humidity between 15% and 90%, as well as wind speeds between 0.1 and 10 m/s, have no influence on sampling rates.

2.4. Quality Assurance and Quality Control

All of the chemicals used during the preparation, extraction and analysis of the samples were analytical and chromatographic grade. The 1-chlorooctane solution used as the internal standard and carbon disulphide (Reagent Plus, redistilled, $\geq 99.9\%$, low benzene) used for the extraction of samples were purchased from Sigma-Aldrich (Sigma-Aldrich, Steinheim, Germany). Radiello[®] diffusive samplers (Code RAD 130) were purchased from Merck. Laboratory and field blanks were analysed to check for any contamination during sample handling and analysis. BTX concentrations detected in the laboratory blanks were found to be below the detection limit of the instrument. On the other hand, trace levels of BTX were measured in the field blanks and they were subtracted from the sample concentrations. Recoveries of the BTX the diffusive samplers were determined according to the instructions from the Radiello manual. To determine the method's detection limit, blank samples were also transferred to the field together with other samplers and were kept close during the sampling period. After that, they were brought to the laboratory and analysed the same way as the other samples. Method detection limits were calculated by using analyte amounts in the field blanks corresponding to a signal-to-noise ratio. Calibration curves were developed using six points based on standard solutions ranging from 1 to 60 ppm. The results showed that the coefficients of determination (R^2) for BTEX contaminants were as follows using the calibration curves: 0.998 for benzene, 0.997 for toluene and 0.998 for xylenes.

2.5. Statistical Analyses of Data

The statistical test of meteorological factors on BTX concentrations included temperature (T , °C), relative humidity (RH, %), wind speed (WS, m/s) and solar radiation (SR). The effect of these factors on BTX concentrations were analysed statistically with the SPSS program (Version 29.00) on a personal computer. The relationships between the BTX concentrations and the meteorological factors were tested with a multiple linear regression (MLR) model and were fitted simultaneously to Equation (3). Regression coefficients deduced from MLR analysis were statistically significant if $p \leq 0.05$.

$$A = C + \beta_1x_1 + \beta_2x_2 + \beta_3x_3 + \beta_4x_4 \quad (3)$$

where A is the dependent variable (BTX), C is the constant of regression, β is a regression coefficient and x_1 through x_4 are the independent variables x_1 (temperature, T , °C), x_2 (wind speed, WS, m/s), x_3 (relative humidity, RH, %) and x_4 (solar radiation, SR). Also, Pearson correlation analysis was applied to all data collected to assess the relationship between BTX and meteorological factors.

3. Results and Discussion

3.1. Benzene, Toluene and Xylene Concentrations

The concentrations for BTX compounds are shown in Figure 3. The results indicated that the predominant BTX compound was toluene, which had the highest concentrations throughout the year compared to other VOCs, with an annual average of $1.48 \mu\text{g}/\text{m}^3$. This finding is in agreement with the results of other studies where toluene was the dominant VOC among BTX compounds in the ambient air [18,35]. The main reason for higher toluene concentrations is that it is usually added to gasoline to enhance octane number and improve fuel efficiency [36]. Toluene was followed by xylene ($0.64 \mu\text{g}/\text{m}^3$) and benzene ($0.61 \mu\text{g}/\text{m}^3$).

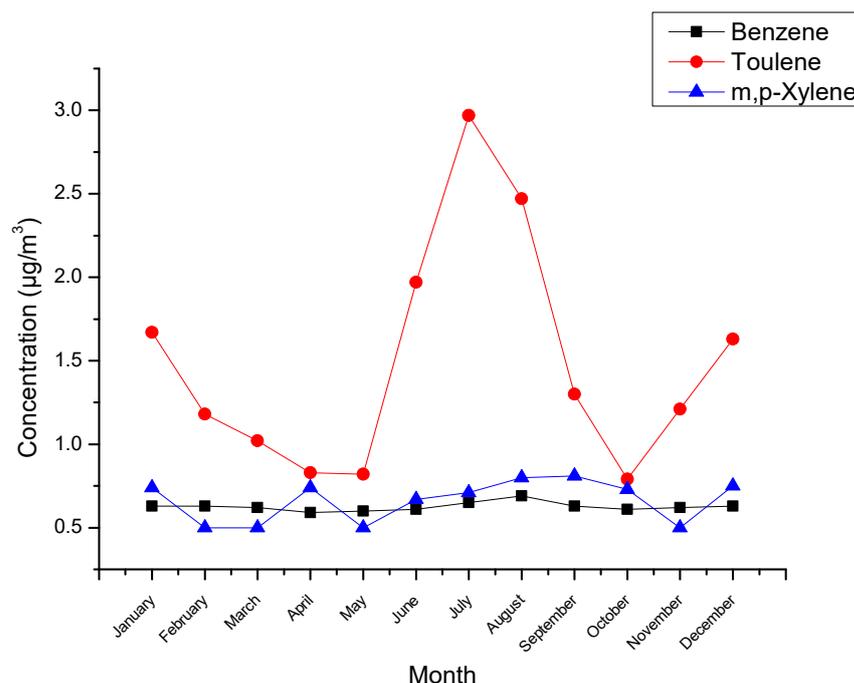


Figure 3. Concentrations of BTX in Steelpoort.

The highest concentrations of toluene and xylene were observed in winter (June–August), whereas the benzene level was high in late winter and early spring (September). This is due to the increased emissions from heating devices as well as emissions from vehicle traffic. It has also been reported that a lower average ambient temperature aids the accumulation of pollutants in the atmosphere, due to the limited movement of air masses in the vertical plane [37]. The results are in agreement with those obtained by other studies in which toluene was reported to have the highest concentrations of BTX [38–40]. For example, the values of benzene, toluene and *m,p*-xylene reported by [40] are $598.34 \mu\text{g}/\text{m}^3$, $1054.32 \mu\text{g}/\text{m}^3$ and $1076.29 \mu\text{g}/\text{m}^3$, respectively. The concentrations of benzene and toluene were lower than the world governing bodies' annual exposure limits, which are $5 \mu\text{g}/\text{m}^3$ (annually) and $260 \mu\text{g}/\text{m}^3$ (weekly) for benzene and toluene, respectively. The Limpopo provincial government of South Africa has monitoring programs for BTX, but the monitoring stations are poorly serviced.

Steelpoort is cold in winter and temperature inversions are more common during this season [41]. A temperature inversion occurs when a layer of warm air traps cooler air near the surface. This stable atmospheric condition can prevent vertical mixing of the air and pollutants, leading to the accumulation of pollutants, including benzene, toluene and xylene, at ground level [42,43]. With limited dispersion, pollutants are trapped near the surface, resulting in higher concentrations. The minimal values of benzene, toluene and xylene were observed during summertime. Benzene and toluene are known to be sensitive to photochemical reactions, therefore an increase in temperature causes their concentrations to be low [44]. The South African summer is usually a rainy season and rain with other forms of precipitation can help remove these compounds from the atmosphere by washing them out of the air [45,46]. This process, known as wet deposition, can temporarily reduce pollutant levels. There is also a lot of traffic in the area due to the transportation of minerals which introduces a lot of pollution from the vehicles. About 3% of the Steelpoort population [47] depends on coal for cooking and this influences the concentrations of VOCs. Therefore, the high concentrations of toluene were mainly attributed to the combustion of fossil fuel (e.g., domestic coal) for heating during the winter. This observation agreed with research reported in rural regions where BTX was mainly attributed to the combustion of fossil fuel (e.g., domestic coal) for heating during the winter [48].

3.2. Interspecies Ratios among BTX

Interspecies ratios were used to identify the potential emission sources of BTX [22,47]. Table 1 shows the BTX interspecies ratios under study. Since Steelpoort is a mining area and a lot of heavy vehicles are used to transport minerals, BTX interspecies ratios were used to identify these VOC sources. Interspecies ratios are affected by BTX source, BTX degradation rates, distance from the source and meteorological factors such as solar radiation, temperature, wind speed, wind direction and relative humidity. Therefore, T/B ratios between two and three indicate mobile sources, while values between three and four indicate that the sampling may be under the influence of mobile and evaporative sources. Values greater than four indicate point sources of BTX or industrial regions. The T/B ratios between two and three, indicate gasoline as a source of the VOCs. Furthermore, the ratio of 4.6 between benzene and toluene in winter shows that they are emitted from other sources such as industrial processes and vehicular emissions [49]. In this study, the calculated T/B ratio range from 1.3 to 4.6 for outdoor BTX concentrations confirms traffic as the emission source. This range was comparable to those measured in southern Taiwan [3]. Also, the T/X ratios are above a value of one, indicating that the vehicles are the source of emission. The X/B ratios range between 0.56 and 1.96, and these low X/B ratios indicate that the air mass in the study area is photochemically aged. For example, it could be aged via reactions with hydroxyl radicals. Benzene has a relatively low reactivity as compared with xylenes. Hydroxyl radicals are extremely short-lived species and play the key role as the chemical scavengers of the atmosphere in cleansing the earth's atmosphere of harmful organic pollutants [48]. Also, the small X/B ratio was reported for xylenes stemming from transport [27,49].

Table 1. Interspecies ratios of toluene/benzene (T/B), toluene/xylene (T/X) and xylene/benzene (X/B).

Month	T/B	T/X	X/B
January	2.6	2.3	1.2
February	3.1	2.3	1.9
March	1.6	3.2	0.52
April	1.4	2.5	0.56
May	1.4	1.2	1.1
June	3.2	4.9	0.66
July	4.6	4.2	1.1
August	3.6	3.1	1.2
September	2.1	1.6	1.3
October	1.3	1.1	1.2
November	2.0	1.8	1.1
December	2.5	2.2	1.2

3.3. Multiple Linear Regression Data

To estimate how the BTX concentrations depend on meteorological factors an MLR was performed. The dependent variables (A) were the BTX mass concentrations, whereas the independent variables were temperature (β_1), wind speed (β_2), relative humidity (β_3) and solar radiation (β_4). The backward elimination of MLR analysis was applied to filter the independent variables (criterion: probability of F to remove ≥ 0.10 , with 95% confidence interval). The MLR coefficients of BTX concentrations with respect to meteorological parameters are illustrated in Table 1. The initial models, derived from Equation (3) for BTX are given by Equations (4)–(6).

$$A_B = 0.844 - 0.003 T - 0.019 WS - 0.006 RH + 0.001 SR \quad (4)$$

$$A_T = 1.543 - 0.233 T + 1.900 WS + 0.041 RH - 0.001 SR \quad (5)$$

$$A_X = 18.606 - 1.33 T + 15.593 WS + 0.749 RH - 0.178 SR \quad (6)$$

$$A_B = 0.857 - 0.005 RH \quad (7)$$

$$A_T = 3.368 - 0.088 T \quad (8)$$

$$A_X = 38.830 - 0.0125 SR \quad (9)$$

where A_B , A_T and A_X are the dependent variables benzene, toluene and xylene, respectively. Meanwhile T is temperature, WS is wind speed, RH is relative humidity and SR is solar radiation.

The strength of the relationships of meteorological parameters with BTX was measured by the size of β -values. For example, in Equation (4), the β -values for independent variables are 0.003, 0.019, 0.006 and 0.001 for temperature, wind speed, relative humidity and solar radiation, respectively. Equations (4) through (6) show that there were negative correlations between the BTX concentrations with temperature. A negative correlation between benzene and temperature, wind speed and relative humidity, as shown by Equation (4), was observed. A weak positive correlation (0.001) with solar radiation shows that photochemical reactions are influencing the concentrations of benzene, although they are low. A similar study has shown negative correlations between benzene and temperature and wind speed [6]. Equation (5) shows that there are positive correlations of toluene with wind speed (1.900) and relative humidity (0.041). As wind speed and relative humidity increase, toluene concentrations increase. This means that the levels of toluene depend on these meteorological factors. Also, there was a negative weak correlation (-0.001) of toluene with solar radiation, which indicates that the toluene concentration does not depend much on the solar radiation. There was a strong positive correlation of xylene with wind speed (15.593) and moderate relative humidity (0.749). Additionally, there was moderate positive correlation with solar radiation (0.178) and strong negative correlation with temperature (1.33). A strong correlation for xylene and wind speed indicates the difference in the relationship with meteorological factors as compared to benzene and toluene. The correlative coefficients (R) in Table 2 were between 0.519 and 0.718 for the initial and final models of BTX, which show that the positive linear correlations were moderately significant between the dependent variables and independent variables. Final Equations (7)–(9) show variability related to relative humidity, temperature and solar radiation for benzene, toluene and xylene, respectively. Figure 4 shows the scatter plots for the relationship between BTX and meteorological parameters to support the r^2 shown in Table 2. The MLR models were significant, with r^2 values of between 0.269 and 0.640. For toluene, the model explained 52% of the variability in the initial model and 64% of the variability in the final model. For benzene, the model explained 41% of the variability in the initial model and 36% of the variability in the final model. However, for xylene, the model explained 38% of the variability in the initial model and 27% of the variability in the final model.

Table 2. Regression coefficients of BTX mass concentrations in Steelpoort.

Model	V	B		T		X	
		β	<i>p</i> -Value	β	<i>p</i> -Value	β	<i>p</i> -Value
1	C	0.0844	0.003	1.543	0.368	18.606	0.552
	Temp	-0.003	0.814	-0.223	0.047	-1.331	0.465
	WS	-0.019	0.894	1.900	0.148	15.593	0.496
	RH	-0.006	0.244	0.041	0.317	0.749	0.329
	SR	0.001	0.485	-0.001	0.907	-0.178	0.217
	R	0.642		0.718		0.619	
	r^2	0.413		0.516		0.383	

Table 2. Cont.

Model		B		T		X	
2	C	0.826	<0.001	1.561	0.327	32.799	0.167
	Temp	−0.004	0.600	−0.224	0.032	−0.419	0.720
	WS	(-)		1.838	0.099	(-)	
	RH	−0.005	0.062	0.039	0.224	0.328	0.430
	SR	0.001	0.445	(-)		−0.137	0.266
	R	0.641		0.718		0.581	
	r ²	0.411		0.515		0.338	
3	C	0.816	<0.001	3.156	0.007	31.744	0.153
	Temp	(-)		−0.132	0.036	(-)	
	WS	(-)		0.832	0.231	(-)	
	RH	−0.005	0.0051	(-)		0.329	0.403
	SR	0.000	0.555	(-)		−0.165	0.070
	R	0.624		0.640		0.572	
	r ²	0.389		0.410		0.327	
4	C	0.857	<0.001	3.368	0.004	38.830	0.061
	Temp	(-)		−0.088	0.064	(-)	
	RH	−0.005	0.038	(-)		(-)	
	SR	(-)		(-)		−0.125	0.084
	R	0.603		0.549		0.519	
	r ²	0.364		0.302		0.269	

Note: V, variable; B, benzene; T, toluene; X, xylene; C, constant; Temp, temperature; WS, wind speed; RH, relative humidity; SR, solar radiation; (-), eliminated; R, correlative coefficients.

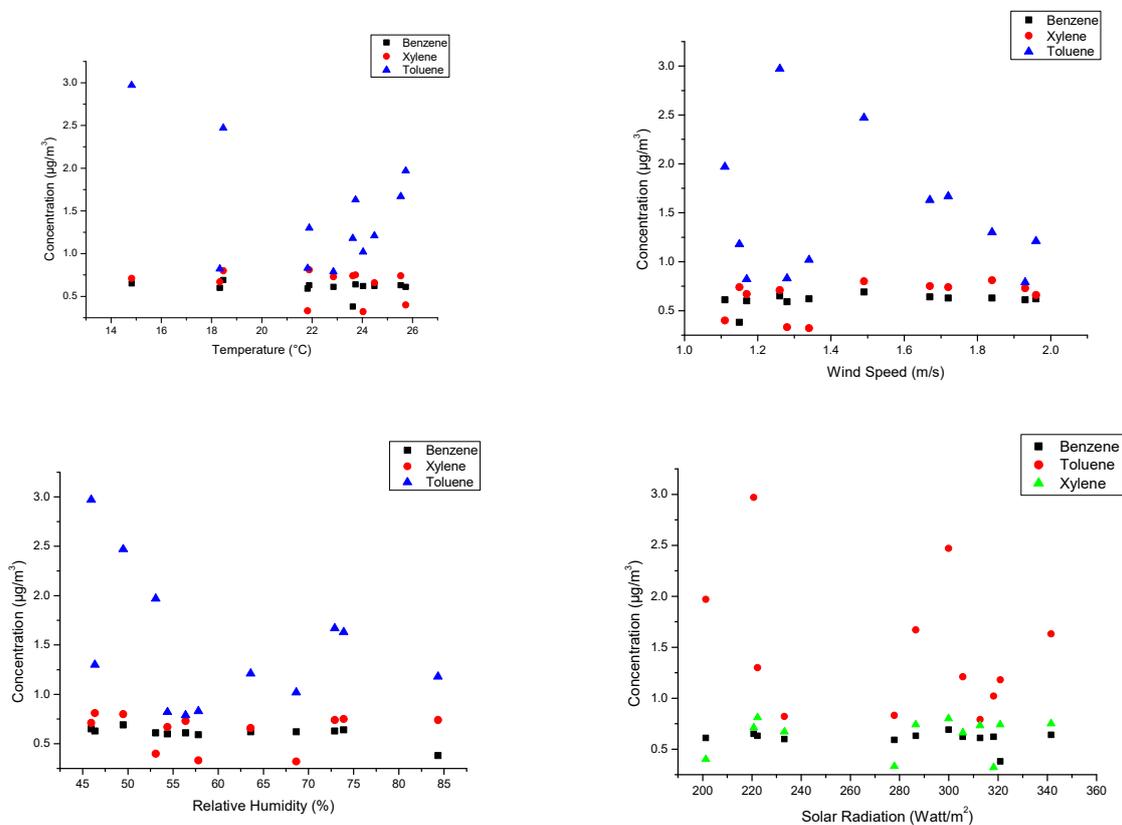


Figure 4. Scatter plots of the relationship between BTX concentrations and meteorological factors.

3.4. Study Limitations

This study had some limitations, which included surveying the ambient air pollutants (BTX) in one residential area in Steelpoort. This was done because the DEFF monitoring station is housed in that area. Furthermore, there was a reliance on the SAAQIS for obtaining data on meteorological parameters. However, the benefit of obtaining data from SAAQIS was that the meteorological data was made available at any time. Section 4 presents the conclusions of the study.

4. Conclusions

The ambient concentrations and possible sources of BTX in Steelpoort are reported in this study. The effects of meteorological parameters on VOCs were also investigated. Among the BTX concentrations investigated, toluene was found to be the most dominant of all VOCs. The highest concentrations of benzene and toluene were observed in winter, whereas the xylene level was high during spring. The minimum values of BTX were observed during summertime due to the South African summer, which is usually a rainy season. Rain with other forms of precipitation helps remove these compounds from the atmosphere by washing them out of the air. The T/B ratios indicated that VOCs are emitted from sources such as industrial processes and vehicular emissions. Statistical models showed both positive and negative correlations of BTX with varying weather conditions. The MLR data show that benzene had a weak negative correlation with temperature, wind speed and relative humidity. A positive correlation of toluene with wind speed and relative humidity shows the dependence on these meteorological parameters. Xylene showed a strong correlation with all meteorological parameters, which indicates that it has a different relationship with these factors as compared to benzene and toluene.

This study shows the need for the implementation of effective actions for controlling industrial and vehicular emissions in the Steelpoort mining area, and for the Limpopo provincial government to make sure air quality standards, as stipulated in the act, are followed, especially for benzene, which is considered carcinogenic to humans. Also, this study is important to the assessment of the technological impacts as well as the maintenance routines of monitoring stations to monitor the industrial and vehicular emissions.

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